GPI: things that worked

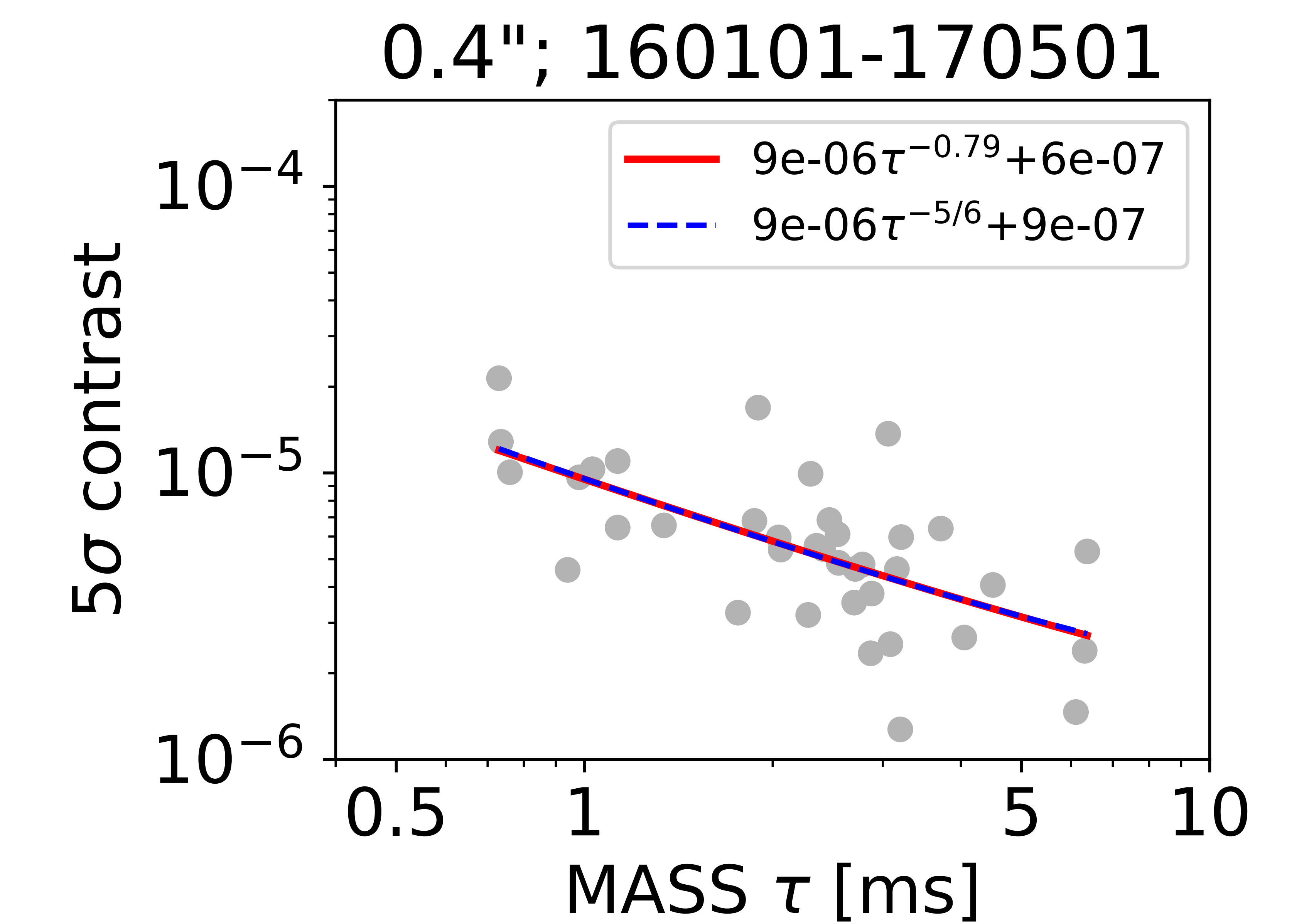
- **Dedicated, effective team has been crucial to GPI productivity (in both commissioning and campaign)**
  - Strong collaboration with observatory
- **Well-constructed and validated data pipeline**
- **High-quality optics and stable structure**
- **Efficient top-level software**
- **Extensive archiving of data and metadata**
- **Flexible interfaces and scripting**
- **MEMS deformable mirror**

GPI: things that could be improved

- **Lack of EMCCD hurts faint-star performance (I=10 mag)**
- **Environmental testing is often too optimistic**
  - Therefore, computation times / frame rate are critical
- **Should have included a ND filter!**
- **Idealized picture of observatory software differs from reality**
  - Software development stalls at ‘good enough’
  - GPI queue utilization limited

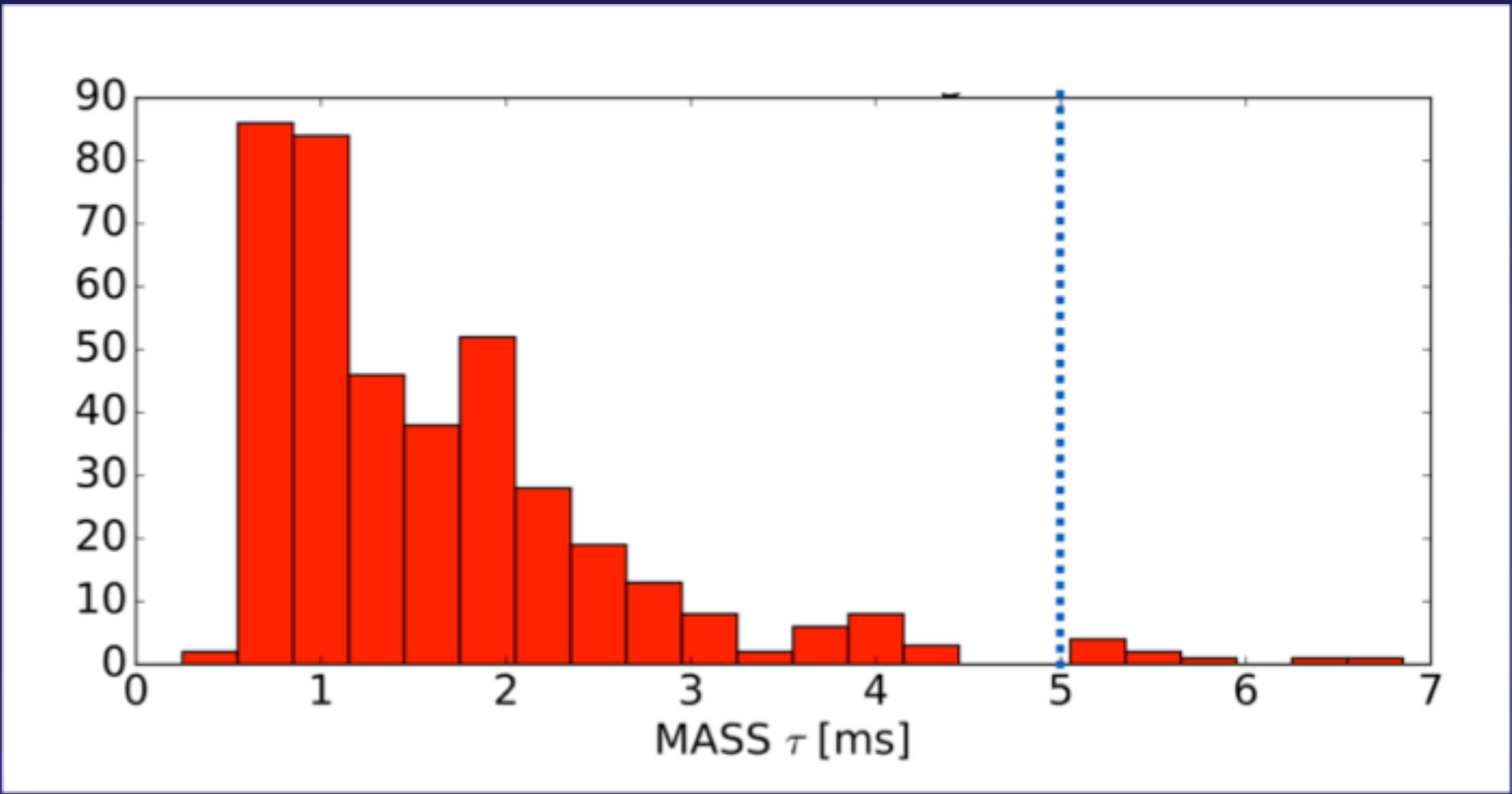
GPI performance

Strongest contrast predictor: tau0

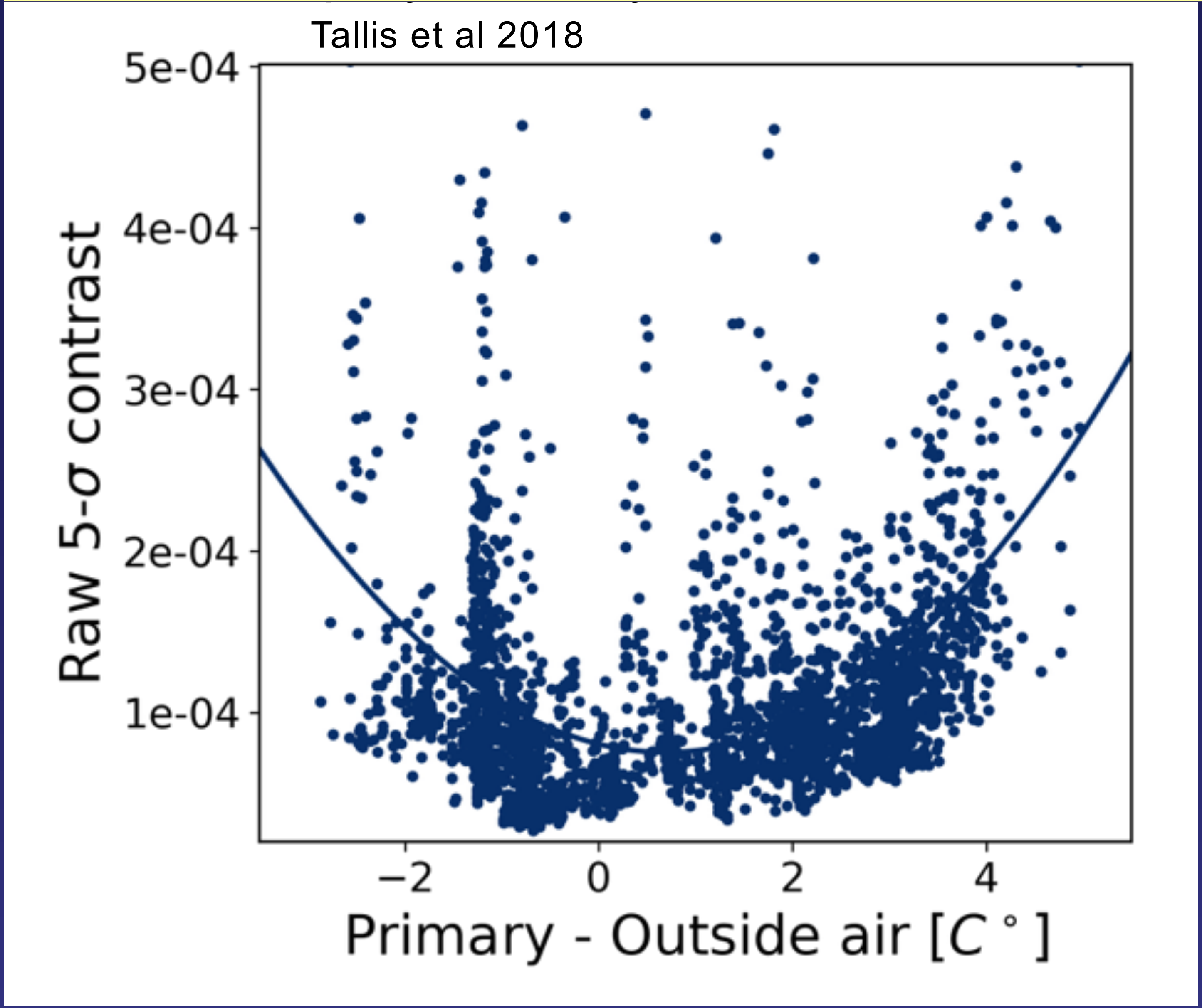


$\tau_0 = r_0/v\_wind$ much worse than predicted

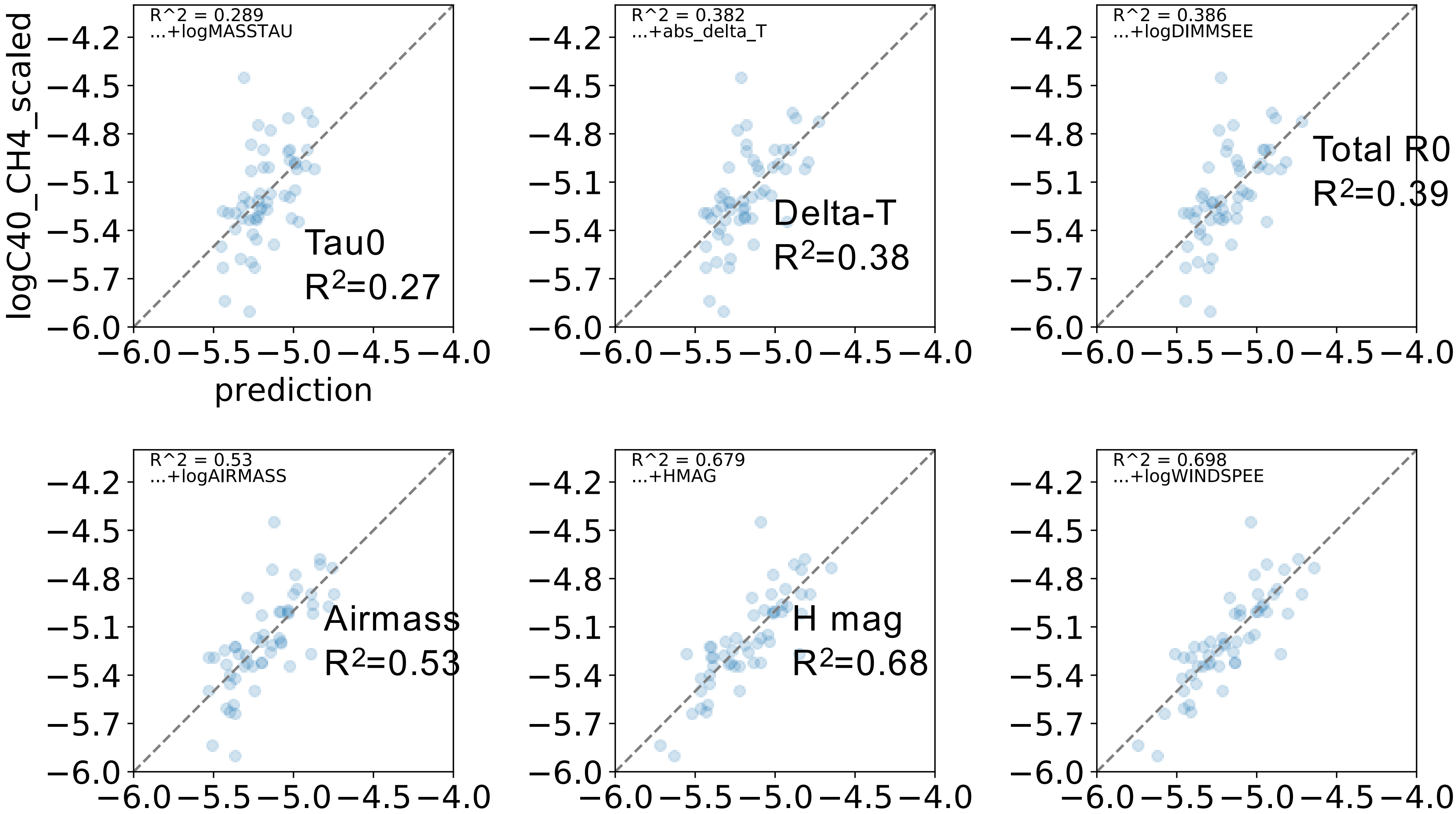
Bad conditions dominated by jet stream – Madurowicz et al 2018



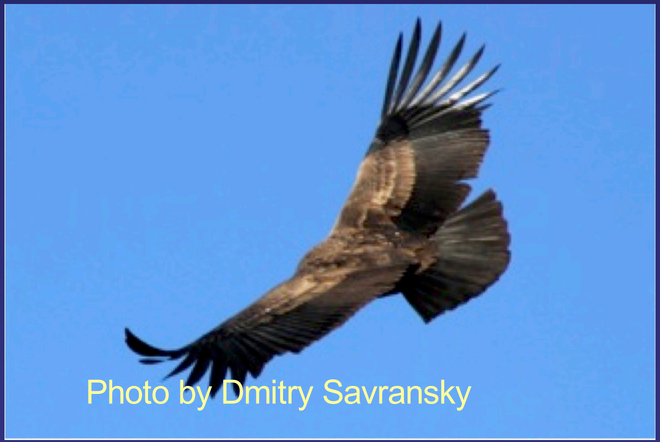
Dome seeing also degrades performance



Integrated contrast model



GPI Relocation



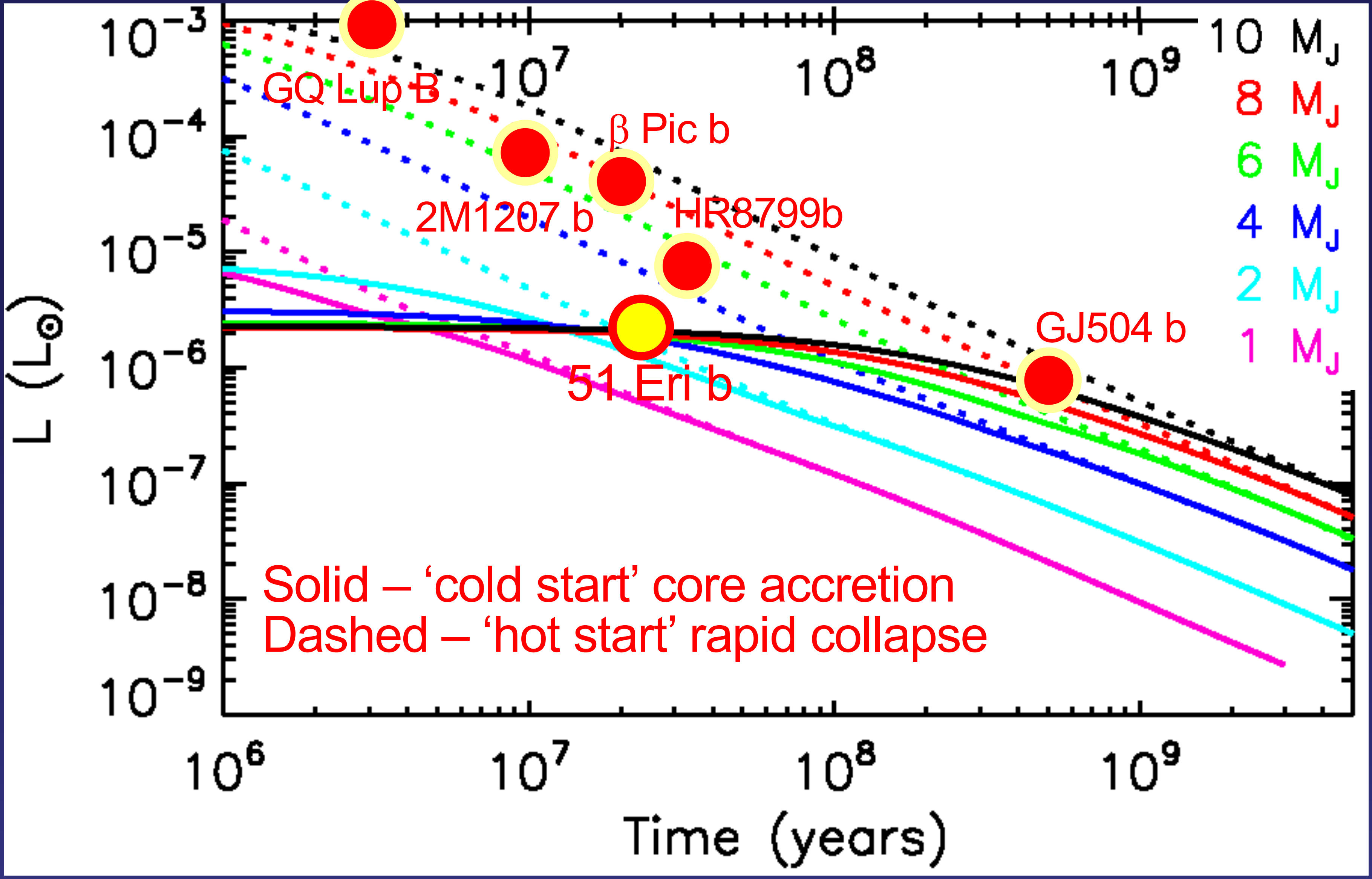
GPI 2 science development

Developing science cases relevant to 2020-2025

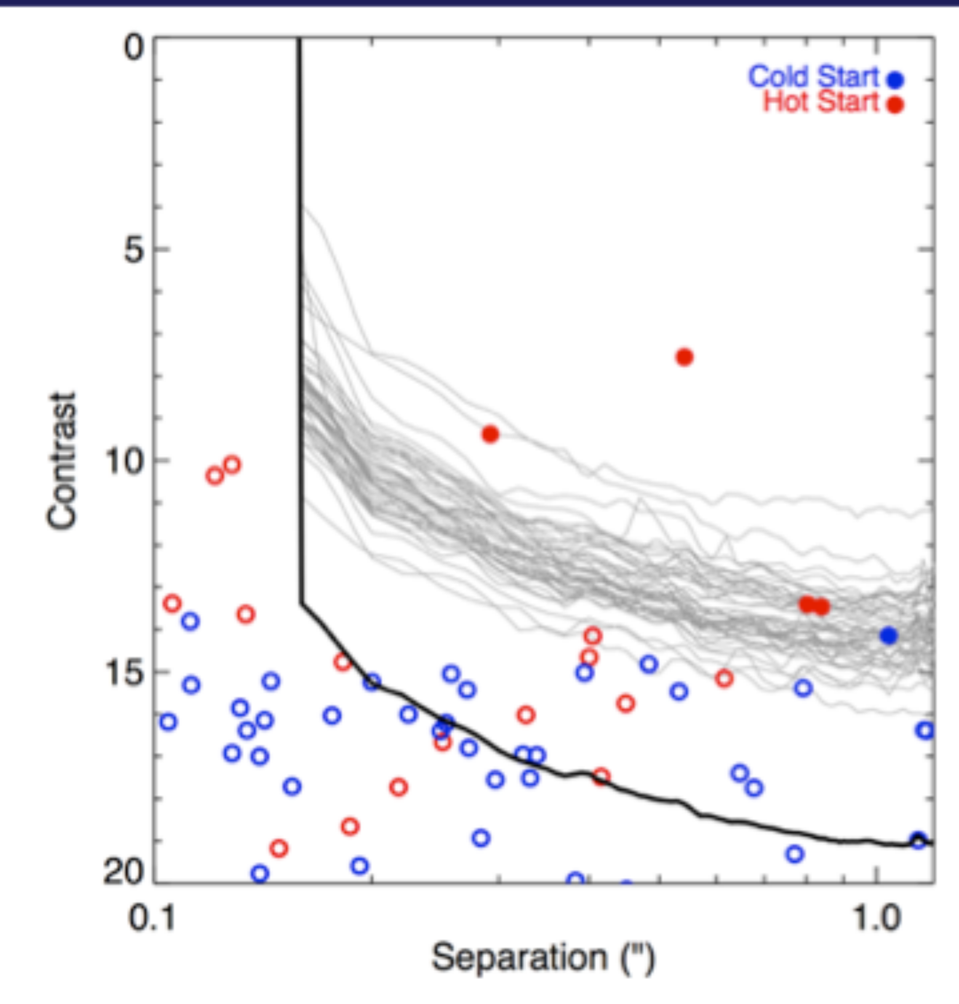
1. Emphasize GPIs strengths: reliable, efficient operation
2. Quantify science requirements -> practical design
3. Complement Subaru and Keck capabilities

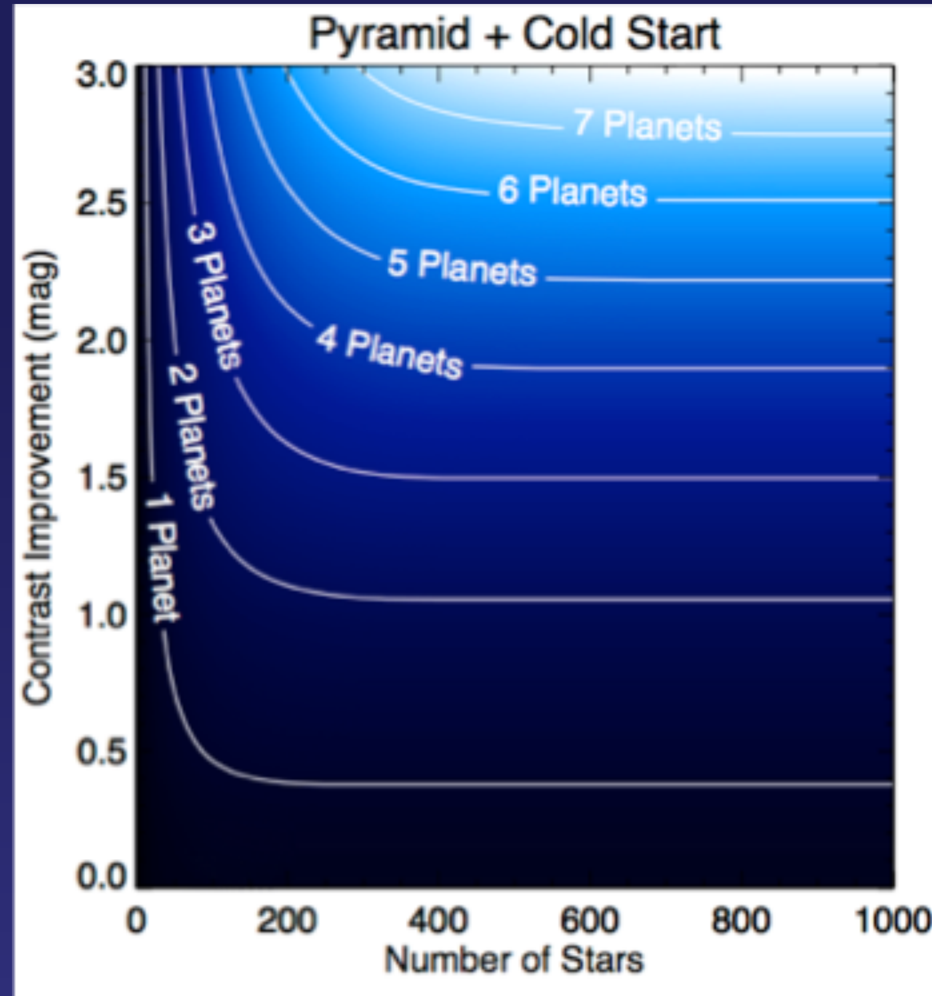
Science Cases	WFS I mag limit	Inner working angle	Contrast Improvement
Large Scale Survey / Cold-start planets	10	0.15	2+ mag
Very young stars + transitional disks	13 (or IR WFS)	0.1"	0
Spectropolarimetry	7	0.15"	1% polarimetry
~~Low-mass Stars~~	~~13~~	~~0.1"~~	~~0~~
Asteroids & Solar System Objects	14	-	0
Debris Disks	9	0.2"	0
Planet Variability & abundance characterization	6	0.2”	1% photometry, high-res spectroscopy feed

“Cold start” planets

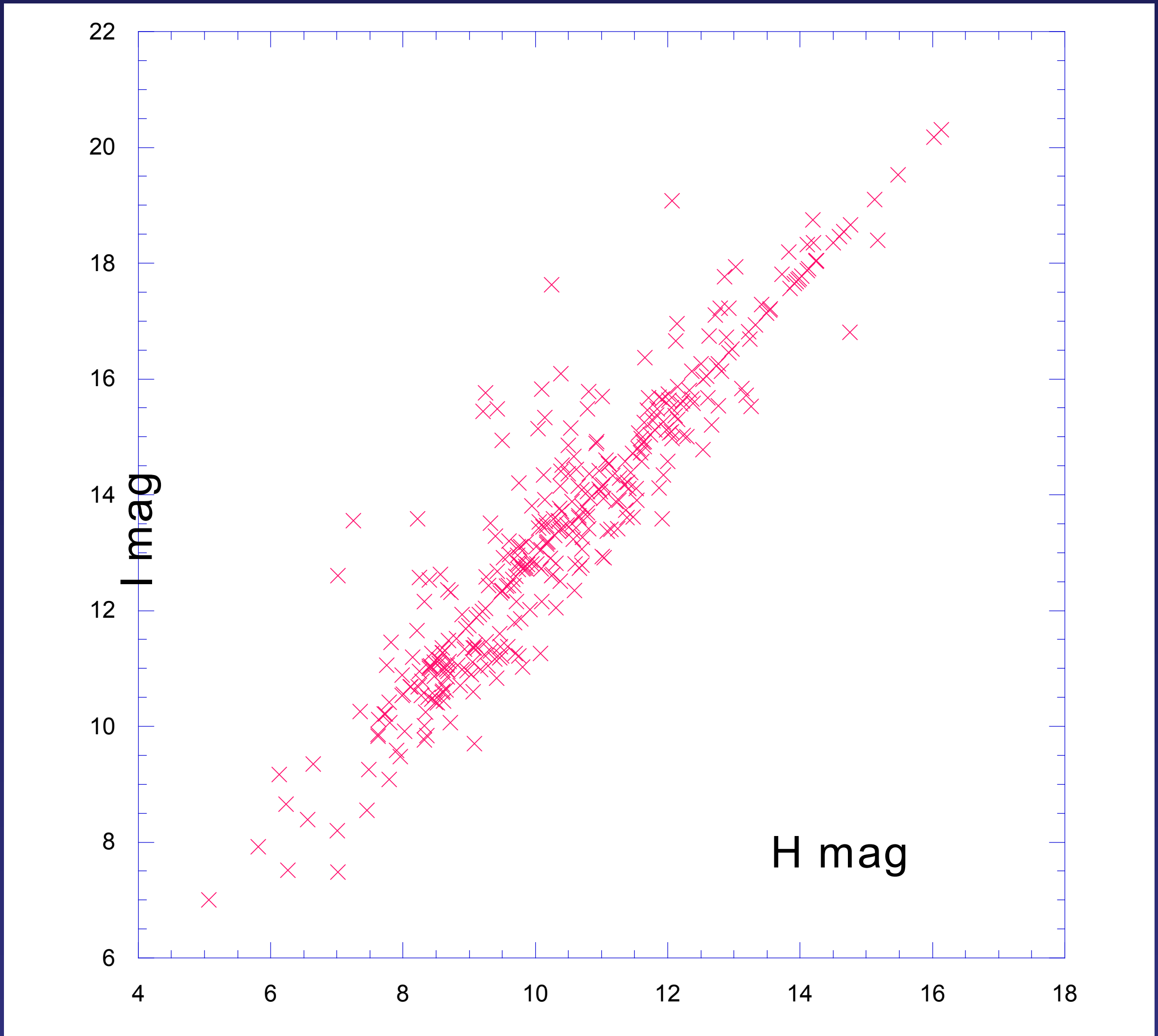


Detecting cold-start planets





Younger planets: Taurus

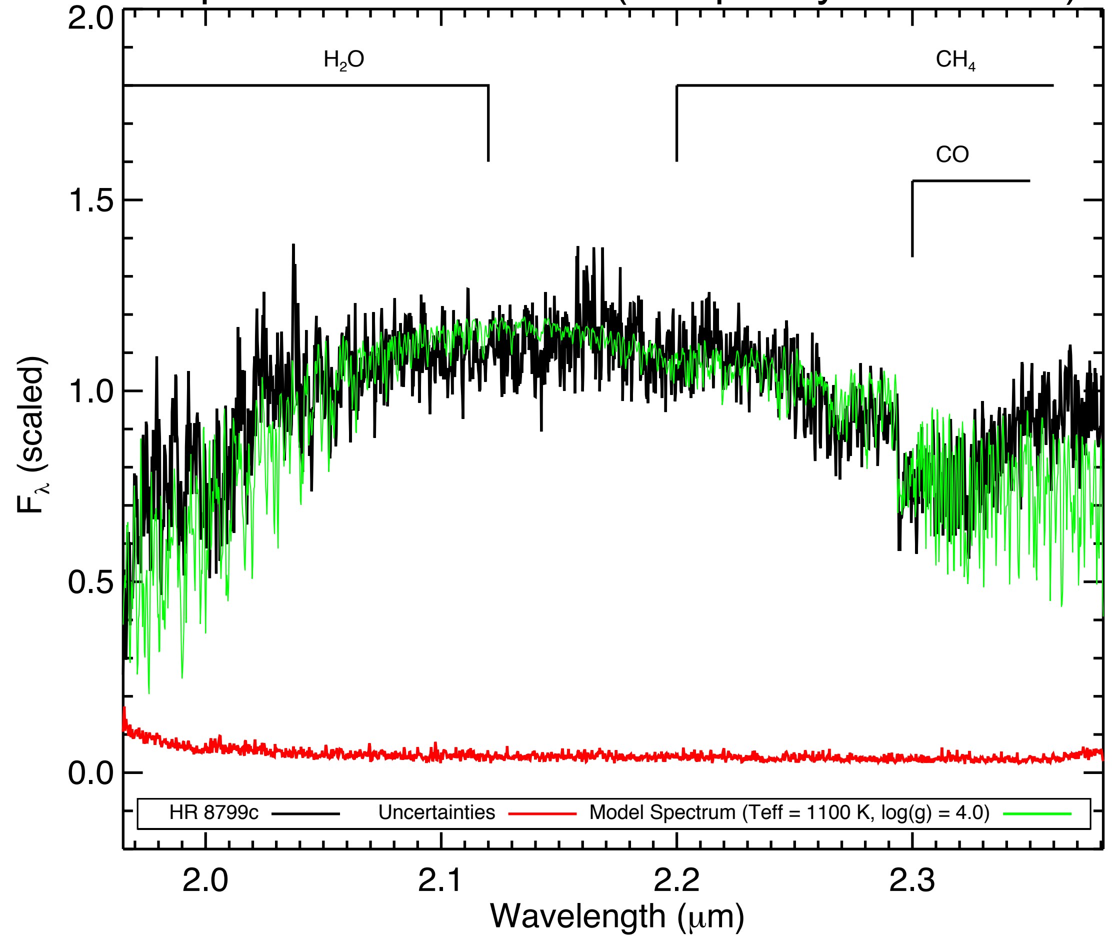


Closest active planet formation?
140 pc, 1-2 Myr
Requires I~13 mag or IR WFS
Desirable: <0.1” IWA

High spectral resolution mode

- High spectral resolution could determine rotational velocity (Snellen et al 2014) and abundances (Konopacky et al 2013)
- Fiber-feed off-bench spectrograph
- Optimal resolution unclear

OSIRIS spectra of HR8799c (Konpacky et al 2013)

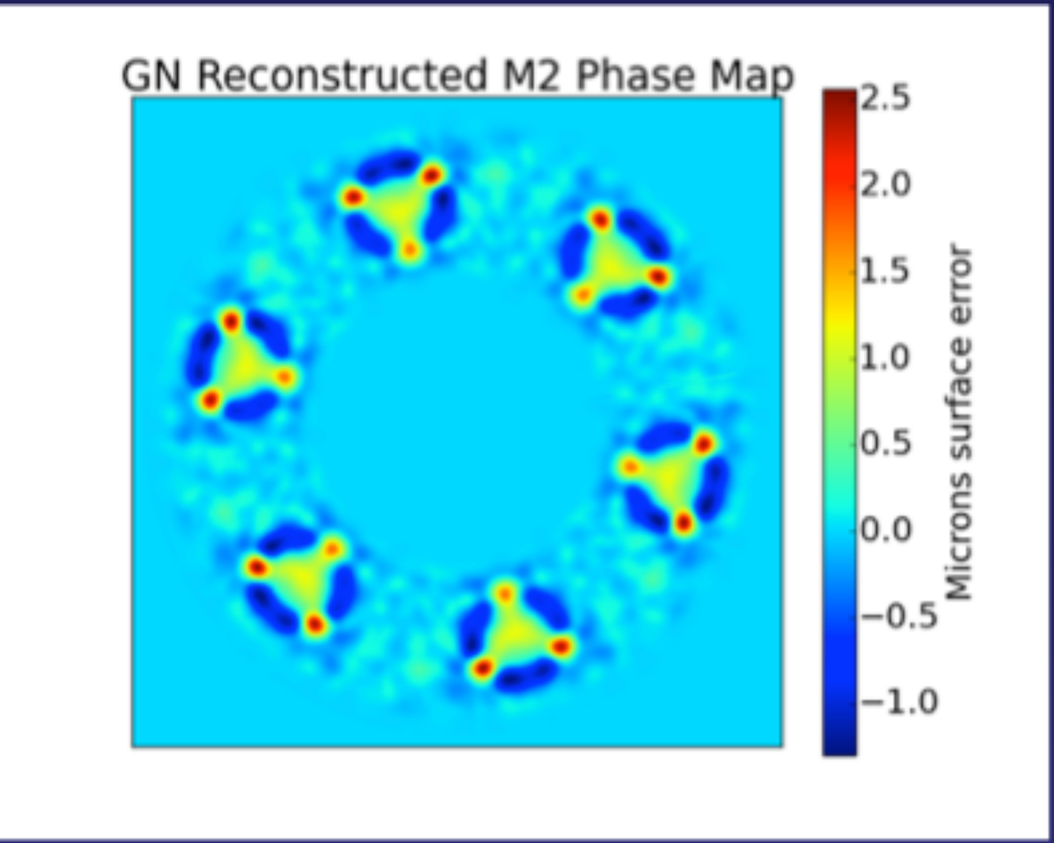


Variability, clouds, rotation

- Rotating planets could be variable at the 1% level
- Combined with high spectral resolution could map out cloud structure
- Are there enough photons?

Luhman 16B (Crossfield et al)

Risks: Gemini North M1 printthrough



GPI 2: Chilcot et al 2018 Proc. SPIE

Build on GPI and observatory's strengths – reliability, data pipeline, survey and monitoring capability

AO: pyramid sensor + 2 kHz + predicive control?

- I=13 mag limit
- 2-4x better contrast close to star

- **IFS**
  - One-shot JHK R~15 mode
  - SpecPol mode
- **Highres spec mode**
  - Fiber-fed R=4,000 or 70,000?
- **Coronagraph**
  - High-throughput broadband mode for surveys and variability
  - Small IWA mode for distant targets
  - Mask M2 bumps?
- **Calibration**
  - Modulated ref spots
  - Fast IR APD camera for imaging and focal-plane WFS (self-coherent, Gerard et al 2018)
  - Precorrect for M2 bump aliasing